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(56) Documents Cited
GB 2244189 A GB 2243055 A WO 85/00258 A1

(58) Field of Search
UK CL (Edition L) H4L LDDRCX LDDRQ LDDSX LDLX LDPX LDSD LDSX LFM
INT CL^5 H04B 7/08 7/26 17/00 17/02, H04Q 7/04
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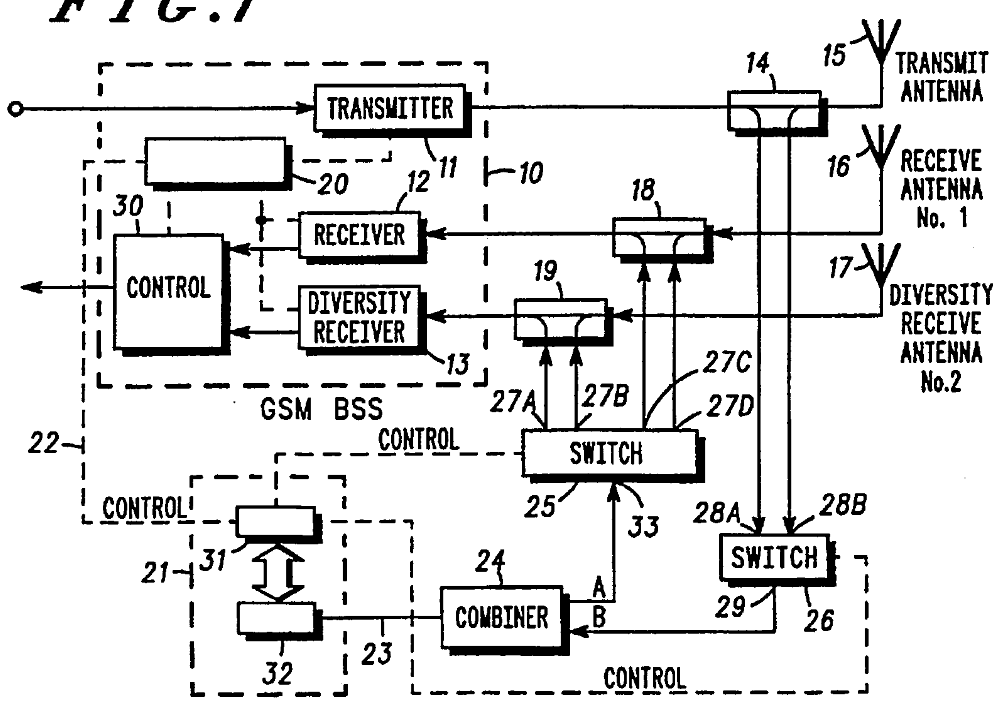
(54) **Radio base station with diversity receiver testing.**

(57) A radio base station 10 is provided, such as a GSM cellular radio base station, comprising at least a pair of space diversity receivers 12, 13 and a base station diagnostics subsystem 21 for testing. The arrangement provides means for comparing a received signal received in a first test with a received signal received in a second test and deducing the relative performance of the receivers in response to the comparison. The test signal is fed selectively to each receiver or signal strength adjusters (attenuators) are changed progressively. The diversity combining operation (e.g. selection combining) can also be tested.

FIG.1



GB 2 272 604 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG.1

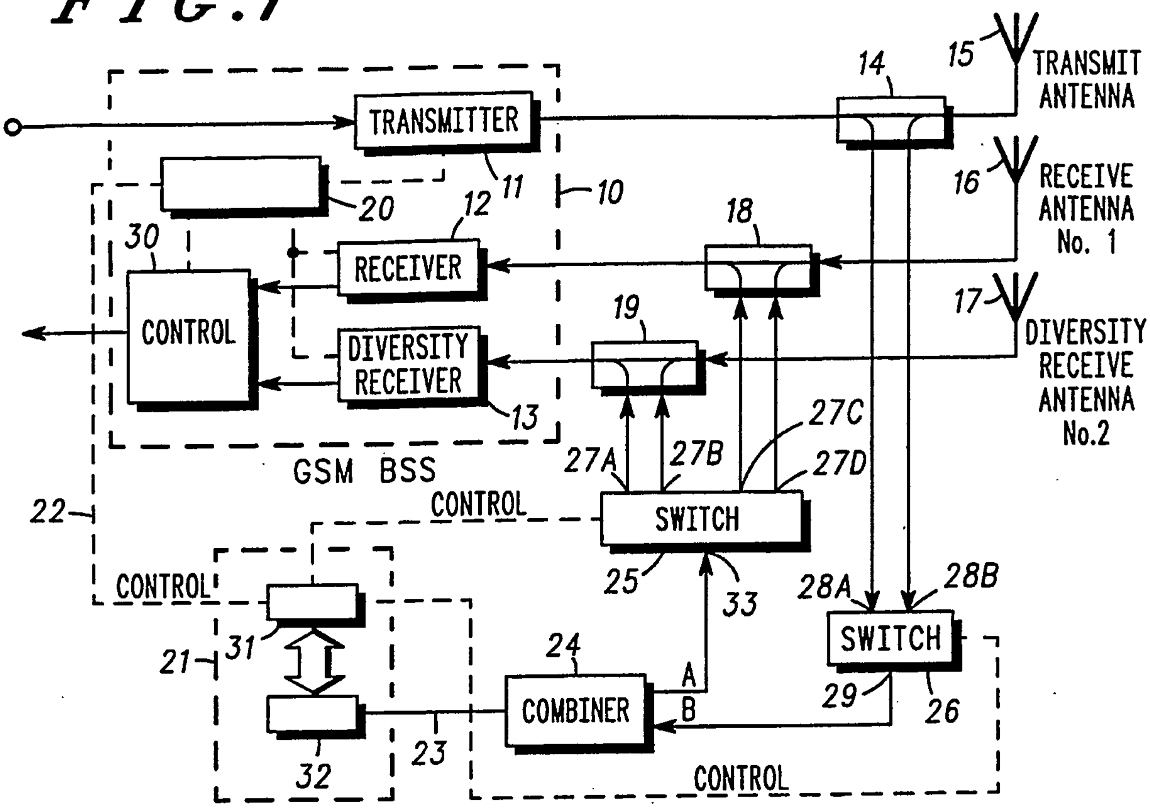

TRANSMITTER
RECEIVER
DIVERSITY RECEIVER
CONTROL
GSM BSS
CONTROL
SWITCH
CONTROL
SWITCH
COMBINER
A
B
CONTROL
TRANSMIT ANTENNA
RECEIVE ANTENNA No. 1
DIVERSITY RECEIVE ANTENNA No.2
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27A
27B
27C
27D
28A
28B
29
30
31
32
33

FIG.2

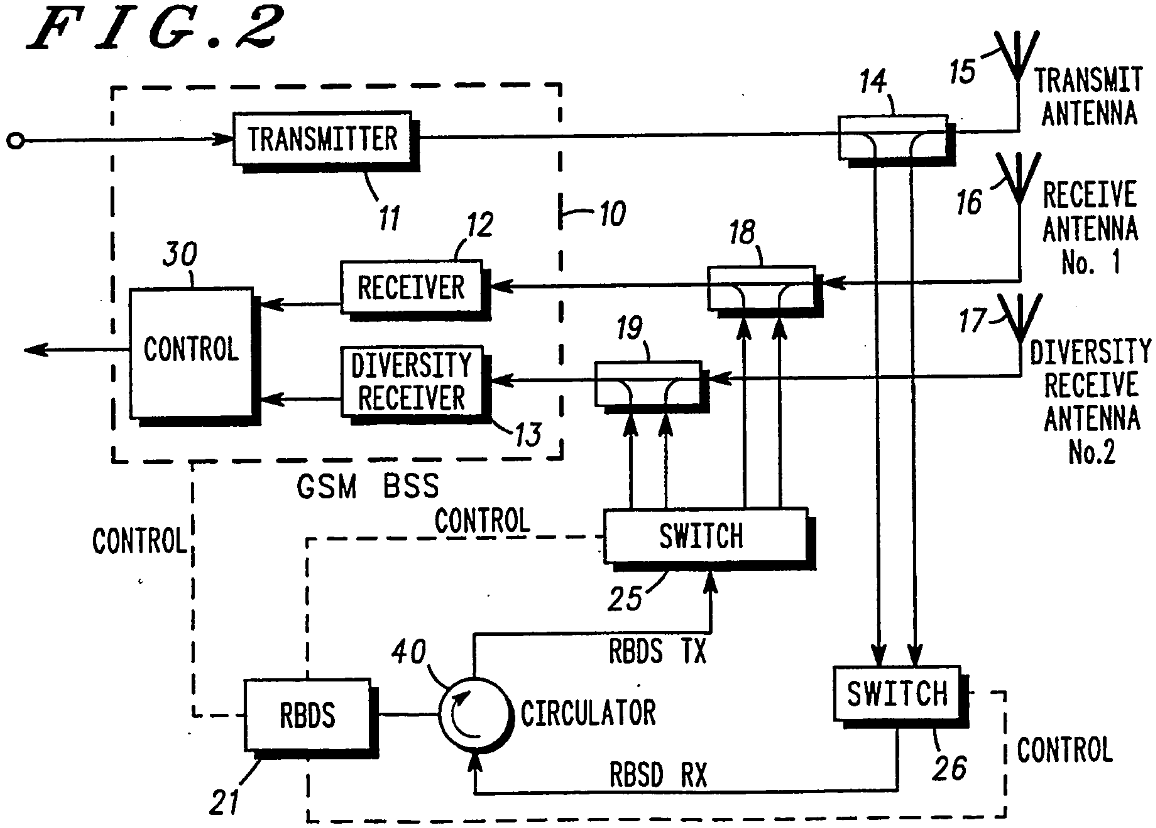

TRANSMITTER
RECEIVER
DIVERSITY RECEIVER
CONTROL
GSM BSS
CONTROL
CONTROL
SWITCH
RBDS TX
RBDS
CIRCULATOR
SWITCH
CONTROL
RBSD RX
TRANSMIT ANTENNA
RECEIVE ANTENNA No. 1
DIVERSITY RECEIVE ANTENNA No.2
10
11
12
13
14
15
16
17
18
19
21
25
26
30
40

FIG.3

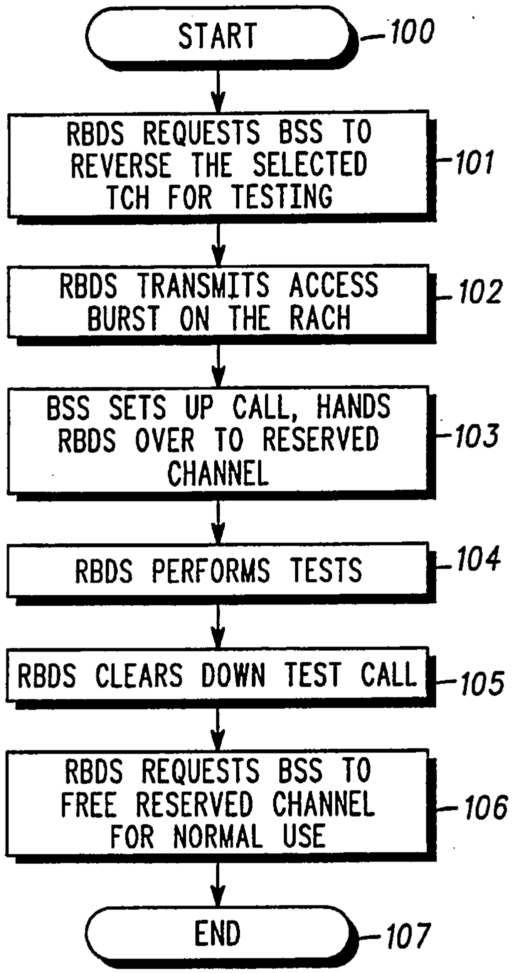

START
100
RBDS REQUESTS BSS TO REVERSE THE SELECTED TCH FOR TESTING
101
RBDS TRANSMITS ACCESS BURST ON THE RACH
102
BSS SETS UP CALL, HANDS RBDS OVER TO RESERVED CHANNEL
103
RBDS PERFORMS TESTS
104
RBDS CLEARS DOWN TEST CALL
105
RBDS REQUESTS BSS TO FREE RESERVED CHANNEL FOR NORMAL USE
106
END
107

FIG.4

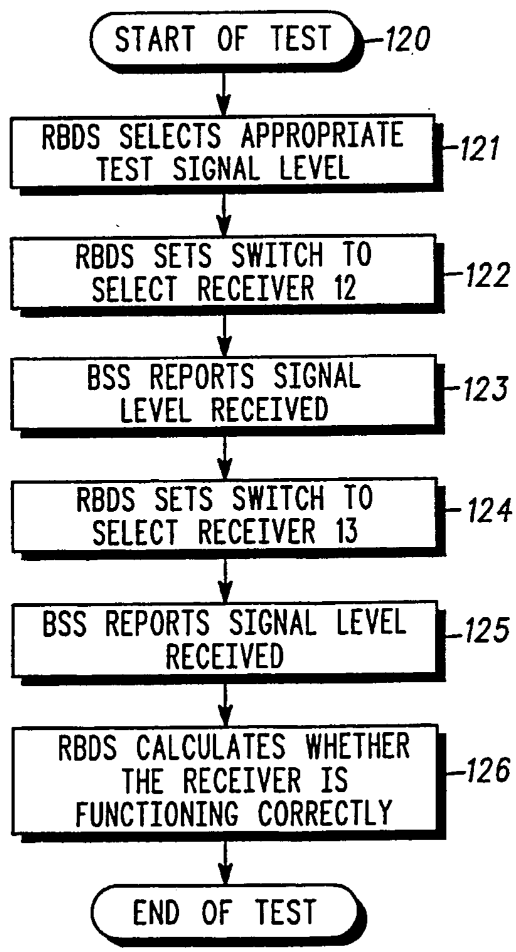

START OF TEST
120
RBDS SELECTS APPROPRIATE TEST SIGNAL LEVEL
121
RBDS SETS SWITCH TO SELECT RECEIVER 12
122
BSS REPORTS SIGNAL LEVEL RECEIVED
123
RBDS SETS SWITCH TO SELECT RECEIVER 13
124
BSS REPORTS SIGNAL LEVEL RECEIVED
125
RBDS CALCULATES WHETHER THE RECEIVER IS FUNCTIONING CORRECTLY
126
END OF TEST

FIG.5

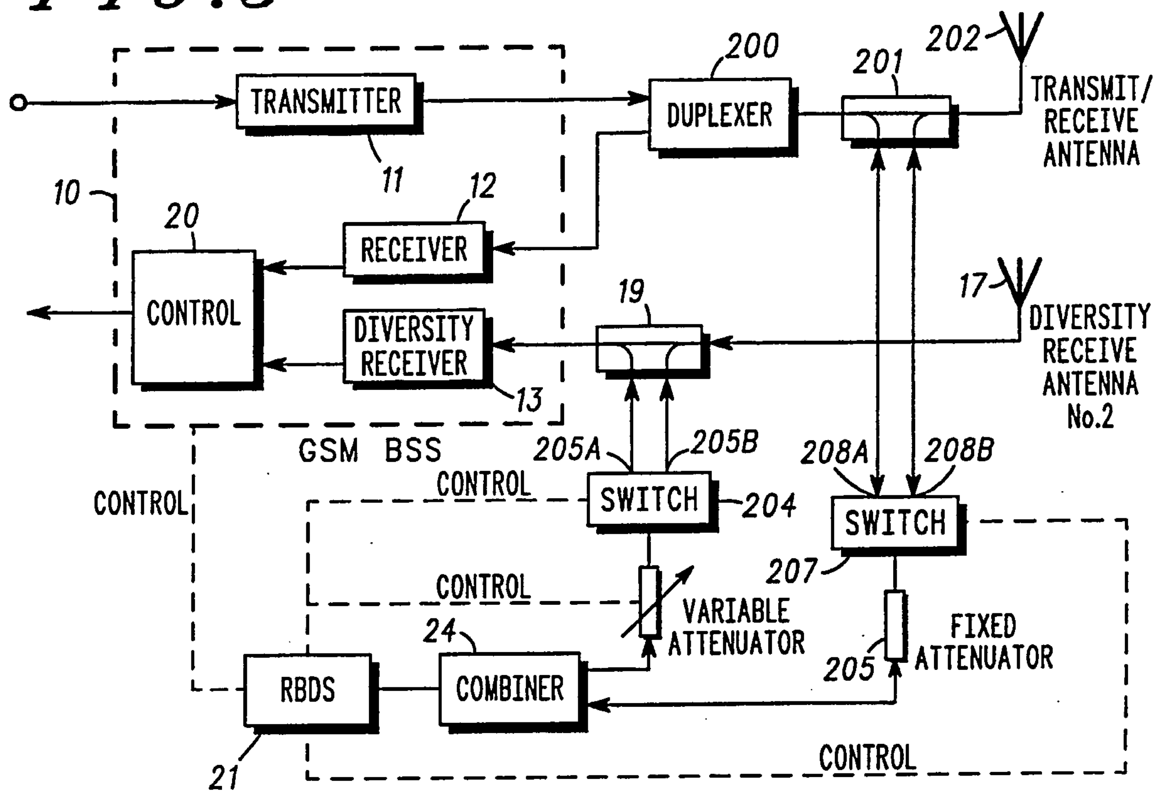
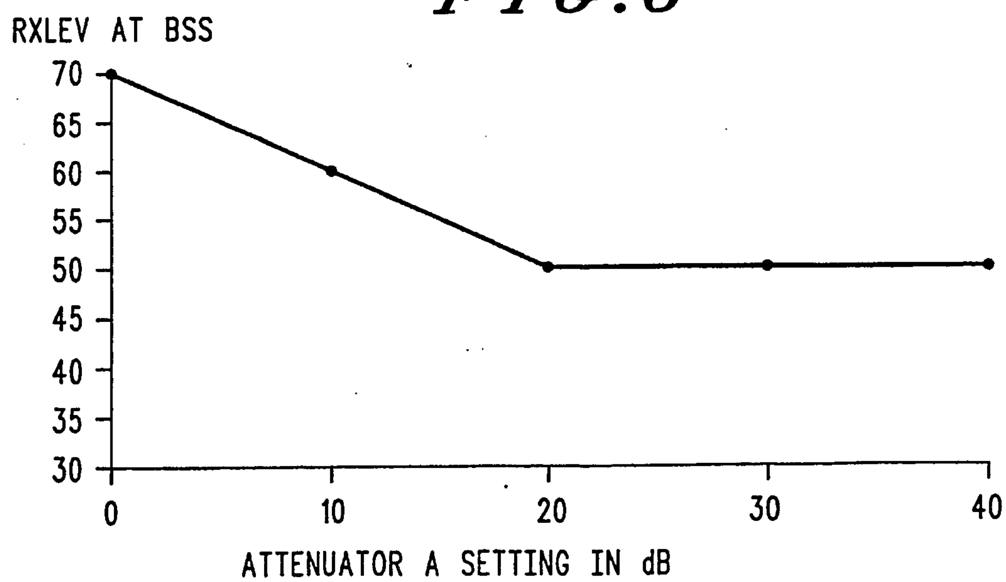

TRANSMITTER
DUPLEXER
200
201
202
TRANSMIT/
RECEIVE
ANTENNA
11
12
10
20
RECEIVER
CONTROL
DIVERSITY
RECEIVER
13
19
17
DIVERSITY
RECEIVE
ANTENNA
No.2
GSM BSS
205A
205B
208A
208B
CONTROL
SWITCH
204
SWITCH
207
VARIABLE
ATTENUATOR
FIXED
ATTENUATOR
205
24
RBDS
COMBINER
21

FIG.6


RXLEV AT BSS
70
65
60
55
50
45
40
35
30
0
10
20
30
40
ATTENUATOR A SETTING IN dB

2272604

RADIO BASE STATION WITH RECEIVER DIVERSITY TESTING

Field of the Invention

This invention relates to a radio base station, such as a GSM cellular radio base station, comprising at least a pair of diversity receivers and a base station diagnostics subsystem for testing.

Background of the Invention

Simple cellular radio base stations have only one receive antenna to receive transmissions from mobiles. To provide improved reception, space diversity is employed in which one transmit antenna and two receive antennas are provided. The transmit antenna is used to transmit signals to mobile stations. The two receive antennas permit the implementation of the space diversity in reception.

Space diversity is a technique which can give large improvements in received signal quality. The inputs from the two receive antennas, separated by a suitable distance, are combined using an appropriate diversity scheme. If one antenna receives a poor signal at a given time due to multipath fading, it is probable that the other antenna is not subject to the same fading.

The signals from the two antennas are diversity-combined by either simple summation or selection of the signal of higher receive strength or by maximal ratio combining. Hereafter, the expression "diversity-combining" is used to refer to any of these or similar techniques.

Patent Application No. GB-A-2,243,055 describes a base station diagnostics subsystems in which a test transceiver is provided associated with the base station and coupled to the base station for sending control signals to the base station and receiving information from the base station. The diagnostics subsystem described in that document is able to test the voltage standing wave ratio (VSWR) of the transmit antenna and is able to test, among other features, the timing advance control software of the base station.

A problem exists with diversity receivers in that a signal that is received by the base station may be adequately received even though one of the pair of receivers is in fact faulty. Thus circumstances may exist where it is not readily apparent that a fault exists.

It would be desirable to provided some mechanism for testing that a receiver having diversity capability is fully functional.

Summary of the Invention

According to the invention, there is provided a radio base station comprising first and second diversity receivers, each having an r.f. receive input and a base station diagnostics subsystem comprising a test transmitter for generating test signals; coupling means for feeding a test signal from the transmitter to each of the diversity receivers, means for diversity-combining the signals received by the first and second receivers to provide an improved received signal; means for reporting to the diagnostic subsystem a parameter (e.g. the level) of the improved received signal; control means for changing the test signal fed to one receiver relative to the test signal fed to the other receiver; and means for comparing the improved received signal received in a first test before changing of the signal with the improved received signal received in a second test after changing of the signal and deducing the relative performance of the receivers in response to said comparison.

In this manner, the diagnostics subsystem can control the feeding of the test signal to the two diversity receivers independently, i.e. relative to one another, and check the received signal in different test situations with different signals being fed to the two receivers.

The control means for changing the signal fed to one receiver relative to the signal fed to the other receiver may comprise switch means for selectively feeding this test signal to each of the first and second receivers selectively, or it may comprise signal strength adjustment means (for example an adjustable attenuator) for progressively changing the signal strength of one signal relative to the other signal.

It will be noted that a test can be set up by means of the invention which will provide a definitive test result by measuring the improved received signal after the diversity combining operation, irrespective of the method of diversity combining (i.e. maximal ratio, combination or selection diversity combining).

The preferred form of diversity combining is selection combining and it is further preferred that means are provided in the base station for reporting to the diagnostics subsystem the particular signal that is selected for providing the improved received signal. That is to say, the diversity selection algorithm reports to the diagnostics subsystem the results of its selection decisions. In this way, the combining operation itself can also be tested.

Preferred embodiments of the invention are now described, by way of example only, with reference to the drawings.

Brief Description of the Drawings

Fig 1. shows a base station and diagnostics subsystem in accordance with a first embodiment of the invention;

Fig. 2 shows an alternative arrangement to that of Fig. 1;

Fig. 3 is a flow diagram showing the operation of the equipment of Fig.1 or Fig. 2 during a test;

Fig. 4 is a flow diagram showing the details of a test operation of Fig. 3;

Fig. 5 shows a base station and diagnostic subsystem in accordance with a third embodiment of the invention;

Fig. 6 shows the RF receive level at the base station for different settings of the variable attenuator of Fig. 5 in normal operation.

Detailed Description of the Preferred Embodiment

Referring to Fig. 1, there is shown a GSM base station 10 comprising a transmitter part 11 and two receivers 12 and 13. Receiver 13 is labelled "diversity receiver", but in fact receivers 12 and 13 are substantially identical. Transmitter 11 is connected via a bi-directional coupler 14 to a transmit antenna 15. Receiver

antennas 16 and 17 are connected via bi-directional couplers 18 and 19 to receivers 12 and 13 respectively. Control circuitry 20 is provided in the base station 10 for control of call set-up, including channel selection and receiver selection as is described below. Diversity control circuitry 30 is provided for selection diversity combining.

In Fig.1, a remote base station diagnostics subsystem (RBDS) 21 is shown. Details of a more basic RBDS are described in GB-A-2,243,055. The RBDS is in effect a test "mobile" co-located with the base station 10 and having a direct control connection 22 in the form of a control bus between control circuitry 20 and RBDS 21.

Note that the control connection between the RBDS and the base station is used for passing test requests from the RBDS to the base station and test results from the base station to the RBDS.

The RBDS itself has two main internal elements. The first is a controller 31 which operates the RBDS under software control and the second is a modified GSM mobile station 32 which is used as a test transceiver.

The RBDS 21 has an RF port 23 which is connected to a combiner 24 for combining and splitting RF signals to and from the port 23 and coupling them to switches 25 and 26. Switch 25 is a four-way switch capable of switching its input 33 to one of four outputs 27a - 27d. These outputs are the forward and reverse paths of bi-directional couplers and 19 and 18 respectively. Switch 26 is a two-way switch allowing one of two inputs 28a and 28b to be connected to its output 29. Inputs 28a and 28b are connected to the forward and reverse paths of bi-directional coupler 14.

In normal operation, the base station 10 transmits and receives radio telephone calls through its transmitter and diversity receivers 12 and 13 under the control of controller 20. The signals received by receiver 12 and diversity receiver 13 are combined by controller 20 either by selecting the stronger of the two signals (selection diversity) or by maximal ratio diversity combining. In the following description, the case of selection combining will be considered.

A number of tests can be carried out by the RBDS 21. The RBDS 21 can perform a VSWR test on each of the antennas 15, 16 and 17. To test antenna 15, the RBDS causes controller 20 to

transmit a test call through transmitter 11. Switch 29 switches first to port 28a and then to port 28b and so allows the forward and reflected signals to and from antenna 15 to be passed through combiner 24 to the RBDS 21. The forward and reverse powers can be compared to determine the quality of the antenna connection. To the test the VSWR of, for example, antenna 16, a test signal is transmitted by the RBDS 21 through output port 27c of the switch 25. The forward power resulting from the signal is measured by receiver 12 and reported to the RBDS. Switch 25 is then switched to port 27d and the signal is transmitted to the antenna 16. Reflected power from the antenna passes to receiver 12 and is also reported to the RBDS.

The testing of the receivers 12 and 13 and the diversity combining function of the control circuitry 20 is as follows.

A test call is set up by the RBDS 21 and a signal transmitted through port 27c of switch 25. This signal is received by receiver 12 and a receive level indication is reported over bus 22 to the RBDS 21. Switch 25 is now switched to provide an output on port 27a and the same signal is transmitted to diversity receiver 13. The received level signal strength after diversity combining is again reported over bus 22. Provided that the receivers 12 and 13 are both functioning normally, the receive signal level will be the same in both parts of the test. If the received signal level falls substantially in the second part of the test, this is an indication that diversity receiver 13 is faulty. Similarly, if the reported signal level from the second part of the test is greater than the signal level in the first part, this is an indication that receiver 12 is faulty.

Referring now to Fig. 2, a similar circuit to that of Fig. 1 is shown in which elements already described have the same reference numerals. In this case, instead of a combiner 24, there is provided a circulator 40. The circulator 40 effectively provides separate receive and transmit paths to the RBDS 21. Signals transmitted by the RBDS are sent to switch 25 by the circulator. Signals transmitted by the base station are routed to the RBDS via switch 26 and the circulator.

Referring to Fig. 3, details of the test operation are shown. At the start of the test 100, the RBDS 21 requests the base station 10 to reserve a selected traffic channel for testing (step 101). The RBDS

now transmits an access burst on the random access control channel (RACH) as shown in step 102. In step 103, the base station sets up a call and hands the RBDS over to the reserved channel - i.e. treating the RBDS as any other mobile, it sends a command over the RF interface to the RBDS instructing it to move to the reserved frequency and timeslot. In step 104, the RBDS performs the tests, one of which is shown in Fig. 4 and is described below. In step 105, the RBDS clears down the test call and in step 106 the RBDS requests the base station to free the reserved channel for normal use.

Referring to Fig. 4, the details of one example of step 104 are shown. The RBDS selects an appropriate test level signal in step 121 - that is to say an appropriate transmission power. The RBDS then sets switch 25 to port 27c to select receiver 12 (step 122). In step 123, the base station reports the signal level of the received signal. This is reported to the RBDS 21. In step 124, the RBDS sets switch 25 to port 27a thereby effectively selecting receiver 13. In step 125, the BSS again reports the signal level received. The signal level reported in steps 123 and 125 is the level after diversity combining and hence does not provide any indication as to the relative signal strengths received through receivers 12 and 13. However, the RBDS now has the information necessary to compare the signal strengths received through receivers 12 and 13 and in step 126 the RBDS calculates (in a microprocessor not shown) whether the receivers 12 and 13 and the associated diversity combiner are functioning correctly.

As a further optional feature, the BSS reports in each of steps 123 and 125 which actual receiver is selected by diversity control circuitry 30.

A further embodiment of the invention is now described with reference to Fig. 5. Those elements which are common to Figs. 1 and 5 have the same reference numerals In the circuit of Fig. 5, a duplexer 200 is connected to the RF output of the transmitter 11 and the RF input of the receiver 12. This duplexer 200 is connected via a bi-directional coupler 201 to a combined transmit and receive antenna 202. The diversity receiver 13 is connected via a bi-directional coupler 19 to a diversity receive antenna as described before. The duplexer 200 allows a single transmit/receive antenna to be used. Connected between the combiner 24 and the bi-

directional coupler 19 is a variable attenuator 203 and a two-way switch 204. The two-way switch 204 has output ports 205a and 205b. Connected between the combiner 24 and the bi-directional coupler 201 is a fixed attenuator 206 and a two-way switch 207 having output ports 208a and 208b.

Note that the dual directional coupler 201 in line with the antenna feed has two main purposes. It provides a defined RF path between the RBDS and the base station and it taps off a small, but defined, proportion of the forward and reverse power passing through the coupler 201. A typical coupling level is 30dB.

There are now two attenuators, one in each path connected to the base station receive inputs. These attenuators allow for a more sophisticated test of the diversity function. The variable attenuator 203 typically has an attenuation value selectable in the range 0-40dB, while the fixed attenuator 206 has a typical attenuation value in the middle of that range at 20dB.

The test proceeds as follows. Initially attenuator 203 is set to 0dB and a test call is set up. The strongest test signal is expected to be received by diversity receiver 13 and, if the receivers are functioning correctly, the base station control circuit 30 will select this path. The attenuation of attenuator 203 is now increased gradually. Diversity receiver 13 still receives the strongest signal until attenuator 203 has a value equalling that of attenuator 206. As the setting of attenuator 203 increases above that of attenuator 206, the control circuit 20 will select receiver 12 since this signal is now larger.

The GSM base station 10 provides a signal level indicating known as RXLEV in 1dB steps and this is used by the RBDS 21 to access the level received by the receiver. The control circuit also informs the RBDS which receiver is receiving the largest signal level.

Fig. 8 shows the results of varying the attenuator setting. The values of RXLEV are plotted against the attenuator value. When the variable attenuator setting is less than the value of the fixed attenuator, the diversity control in the base station reports the RXLEV values from receiver 13. However when the variable attenuation is greater than the fixed value, the diversity control reports constant RXLEV values from receiver 12. This proves with confidence that both receiver paths are functioning. The tests can

be carried out at different signal levels to more fully test the system.

Fixed attenuator 206 can be made variable for more complex tests.

Claims

1. A radio base station comprising first and second diversity receivers, each having an r.f. receive input and a base station diagnostics subsystem comprising

a test transmitter for generating test signals;

coupling means for feeding a test signal from the transmitter to each of the diversity receivers,

means for diversity-combining the signals received by the first and second receivers to provide an improved received signal;

means for reporting to the diagnostic subsystem a parameter of the improved received signal;

control means for changing the test signal fed to one receiver relative to the test signal fed to the other receiver; and

means for comparing the improved received signal received in a first test before changing of the signal with the improved received signal received in a second test after changing of the signal and deducing the relative performance of the receivers in response to said comparison.

2. A base station according to claim 1 wherein the control means for changing the signal fed to one receiver relative to the signal fed to the other receiver comprise switch means for selectively feeding the test signal to each of the first and second receivers selectively.

3. A base station according to claim 1 wherein the control means for changing the signal fed to one receiver relative to the signal fed to the other receiver comprise signal strength adjustment means for progressively changing the signal strength of one signal relative to the other signal.

4. A base station according to claim 3, wherein the adjustment means comprise at least one variable attenuator.

5. A base station according to claim 4, wherein the adjustment means comprise a variable attenuator coupled between the test

transmitter and one receiver and a fixed attenuator coupled between the test transmitter and the other receiver.

6. A base station according to any one of the preceding claims comprising a transmitter, a duplexer and a transmit and receive antenna, where the duplexer couples the transmitter and one of the receivers to the transmit and receive antenna and means for feeding the test signal through the duplexer to the receiver which is coupled to the duplexer.

7. A base station according to any one of the preceding claims comprising a transmit antenna port and a circulator for coupling signals from the diagnostics subsystem to the receivers and for coupling signals from the transmit antenna port to the diagnostics subsystem.

8. A base station according to any one of the preceding claims wherein the means for diversity-combining comprise selector means for selecting one of the signals from the first and second receivers to provide the improved received signal and comprising means for reporting to the diagnostic subsystem the selection between the the signals from the first and second receivers that is made by the selector means at a given time.

9. A base station substantially as hereinbebore described and as shown in any one of Fig. 1, 2 and 5.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
GB 9223509.2

Relevant Technical fields

(i) UK Cl (Edition L) H4L (LDDRCX, LDDRQ, LDDSX, LDLX, LDPX, LDSD, LDSX, LFM)

(ii) Int Cl (Edition 5) H04B 7/26, 7/08, 17/00, 17/02; H04Q 7/04

Search Examiner

K WILLIAMS

Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI

Date of Search

20 January 1993

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2244189 A (ORBITEL MOBILE COMM) see abstract	1, 8
A	GB 2243055 A (MOTOROLA) see Claim 1; & WO 91/15904 A1	1
A	WO 85/00258 A1 (MOTOROLA) see abstract	1

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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